An Advanced Polymer PV System

Highlights

- Developed a new polymer backskin that allows the use of frameless modules
- Developed a new encapsulant to replace EVA and an in-air lamination method using the new encapsulant
- Designed a frameless module line that employs the new backskin, new encapsulant, and new mounting methods
- Dropped the cost of module manufacturing by $0.50 per watt

This Evergreen Solar project is part of the 1995 solicitation of PVMaT—a cost-shared partnership between the U.S. Department of Energy and the U.S. PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.

PVMaT Fact Sheet

Photovoltaic Manufacturing Technology

Evergreen Solar, Inc.

Goal

Under this 2-year 1995 PVMaT solicitation project, Evergreen Solar's goal was to improve PV module construction. Specifically, the company's objectives were to develop:

- a new backskin material that would allow the use of a frameless module
- innovative mounting methods using the new backskin material
- a new encapsulant that would replace ethylene vinyl acetate (EVA) and that would not require vacuum lamination, and
- a continuous, in-air lamination method using the new encapsulant.

The company focused on backskin issues in the first year of the project and the encapsulant in the second year.

Technical Approach

One of the consistent long-time goals of the PV industry has been to cut the cost of making PV modules while retaining high module reliability, high conversion efficiency, and long life. For crystalline silicon, there are three general areas in which costs may be cut—in the production of the crystalline material itself, in cell processing, and in module construction.Evergreen is already addressing the first two areas with its silicon String Ribbon technology. With this PVMaT project, the company addressed the category of module construction.

In constructing a typical module, once cells are processed and electrically connected, they are imbedded in EVA between a front glass and a multilayer backskin made of Tedlar. After these components are laminated under high heat and vacuum, the module is fitted with an anodized aluminum frame. The EVA, which is translucent and allows light to enter the cells, encapsulates the cells, providing protection, electrical insulation, and ultraviolet stability. The Tedlar backskin bonds to the EVA and the aluminum frame, and provides protection against weather, moisture, and punctures. The aluminum frame provides mechanical stability and a way to mount the module to structures.

Although EVA has been dependable for the PV industry, some manufacturers and users have reported yellowing and browning under high temperature and intense sunlight. In addition, EVA requires lamination under high heat and a vacuum; this necessitates the use of expensive vacuum equipment. By finding an appropriate alternative to EVA, one that could be laminated in air,Evergreen would cut production costs and improve module reliability.

Jack Hanoka/PIX05935

Four of Evergreen Solar's 60-watt, frameless modules mounted on a simple C channel and aluminum tubing structure. The modules use Evergreen's String Ribbon technology, new backskin and encapsulant, and a microinverter on the back to convert the DC electricity to AC.

The use of Tedlar as a backskin has also served the industry well. Yet, it has its drawbacks: it is expensive (more than $10/m^2); hard to bond to, has been known to delaminate when mounting structures have been bonded to it, requires an edge seal and an aluminum frame, and is not highly resistant to puncture. Therefore, an appropriate substitute for Tedlar would enable Evergreen to cut costs, increase module reliability, eliminate the aluminum frame, and use less-costly mounting strategies.

Results

Evergreen Solar completed the project in 1997, meeting success with every objective. The company developed a new backskin, created innovative mounting methods, replaced EVA with a new encapsulant, and developed an in-air lamination method. As a result, Evergreen is producing a new product line based on frameless modules with the new backskin material and new encapsulant, while saving about $0.50/watt in module manufacturing costs.

New Backskin

To develop a suitable backskin, Evergreen Solar conducted a survey of commercially available materials and selected a polymer that was being used in other major industries, and which could be modified for use in PV modules. The company chose a thermoplastic material that can be formed during the lamination process to seal and frame the module edges, thereby eliminating the need for an aluminum frame and paving the way for a wide variety of low-cost mounting methods.

The material passed all in-house reliability tests, exhibiting no degradation. The tests included the IEEE 1262 humidity freeze test, one of the most stringent environmental stress tests.

Innovative Mounting Methods

The new backskin material enables a wide spectrum of mounting possibilities. For roof mounting, an innovative system was developed that uses aluminum “slide bars.” These bars are bonded onto the backskin, extending slightly beyond the edge of the module. The complete, frameless module is then mounted by simply sliding the module over two pieces of C-channel. For pole mounting, Evergreen Solar has bonded a bent aluminum plate to the backskin and tested it for bond strength, with no apparent problems. The company has also successfully and easily bonded large-area flat-head aluminum bolts.

An added benefit is that the backskin can be heat-bonded to other polymers to produce a module with no junction box; instead, the leads emerge from the backskin material at the edge of the module.

New Encapsulant

Evergreen Solar also researched and chose a newly developed encapsulant that shows considerable promise as a replacement for EVA. The material can be obtained in sheets about 18 mm thick. Unlike EVA, it does not require chemical cross-linking, and consequently, it avoids some of the issues associated with the organic peroxide additives used for cross-linking EVA.

The new encapsulant can be laminated in air and bonds very well with all adjacent surfaces. A new ultraviolet stabilization package has been developed specifically for this encapsulant. Accelerated tests for ultraviolet exposure indicate that the new enhanced encapsulant performs better than EVA.

In-air Lamination

Using the properties of the new encapsulant, a non-vacuum, continuous-lamination method has been developed. A prototype machine that can make modules larger than 60 watts in size has been designed and built, and the basic process parameters have been determined.

Inventions/Patents

A total of six patents were filed from work carried out under this PVMaT contract. Two of these patents have already been granted by the U.S. Patent Office.

Company Profile

Evergreen Solar, Inc., a fully integrated manufacturer of crystalline silicon photovoltaic modules, uses innovative technology in every aspect of solar cell manufacture. The company uses a continuous silicon ribbon growth technology called String Ribbon. Evergreen's patented cell-making technology is unique in the industry; and also has a patented technology in the module area. The latter was funded by a contract under the 1995 solicitation of PVMaT. The company, created in 1994, is located in Waltham, Massachusetts, and now has about 40 employees. The company's founders are Mark Farber, President; Rich Chleboski, V.P., C.F.O.; and Jack Hanoka, V.P., Technology.

References

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